Armed Forces College of Medicine

AFCM

Cartilage

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Histology Department

INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

1- Describe the microscopic structure of cartilage cells and matrix.

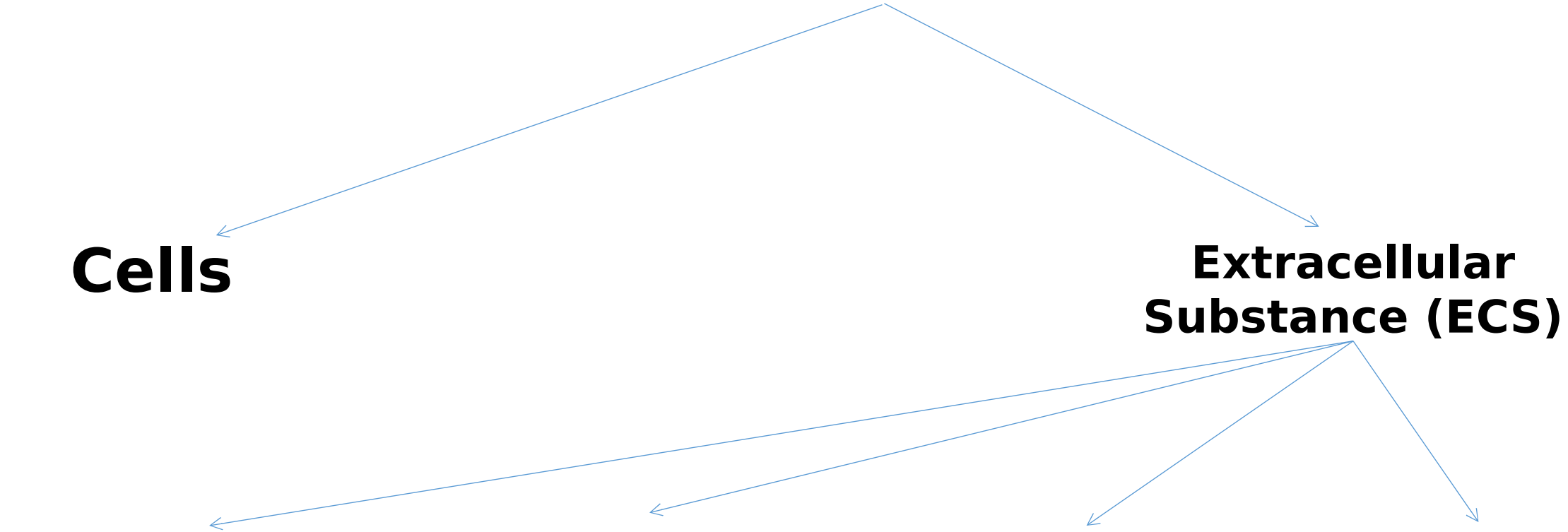
2- Correlate the structure of hyaline cartilage, elastic cartilage and white fibro-cartilage to their function

3- Interpret the defect in the microscopic cartilage structure in different diseases.

Key Points

- Histological structure of hyaline cartilage.
- Histological structure of perichondrium.
- Microscopic structure & function of different types of cartilage cells (chondrogenic, chondroblast and chondrocytes).
- Microscopic structure of the matrix of hyaline cartilage.
- Differentiate between the three different types of cartilage (Hyaline, Elastic & white-fibrocartilage).
- Staining properties of cartilage.
- Nutrition, growth and medical application of cartilage.

Connective Tissue



Cartilage

- Is a special type of connective tissue that has extra cellular matrix of a firm consistency that allows the tissue to bear mechanical stresses without permanent distortion
- Is rigid, rubbery with some degree of flexibility.
- Is well adapted to bear weight.
- **It lacks nerves**
- **No blood vessels within cartilage (avascular).**

Cartilage

- In most places cartilage is covered by **perichondrium** (connective tissue covering)
- The **Cartilage** is formed of:

1- **Cells.**

2- **Fibers (type II collagen)**

3-

Matrix of cartilage

Types of Cartilage

1. **Hyaline cartilage:** having matrix containing **collagen type II** fibers.
2. **Elastic cartilage:** having matrix containing **elastic fibers + collagen type II** fibers.
3. **White fibrocartilage:** containing **collagen type I + collagen type II** in matrix.

Hyaline Cartilage

Is the **most common** type of cartilage in the body.

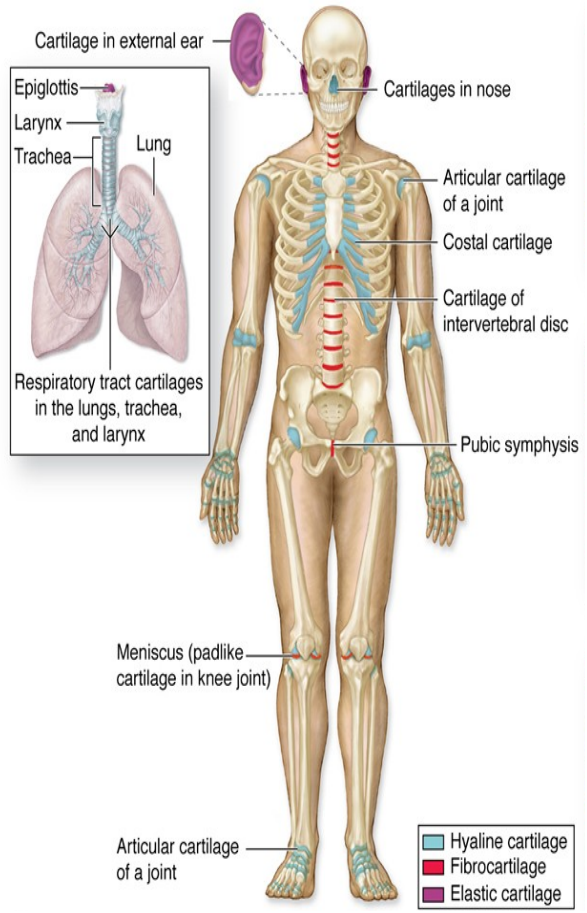
It is semitransparent in the fresh state.

Sites:

-In fetus: is present in fetal skeleton → replaced gradually by bone.

- In adult, it is located in:

1. Articular surfaces of bone in joints.
2. Costal cartilage.
3. Respiratory passages
4. Epiphyseal plates of long bone.



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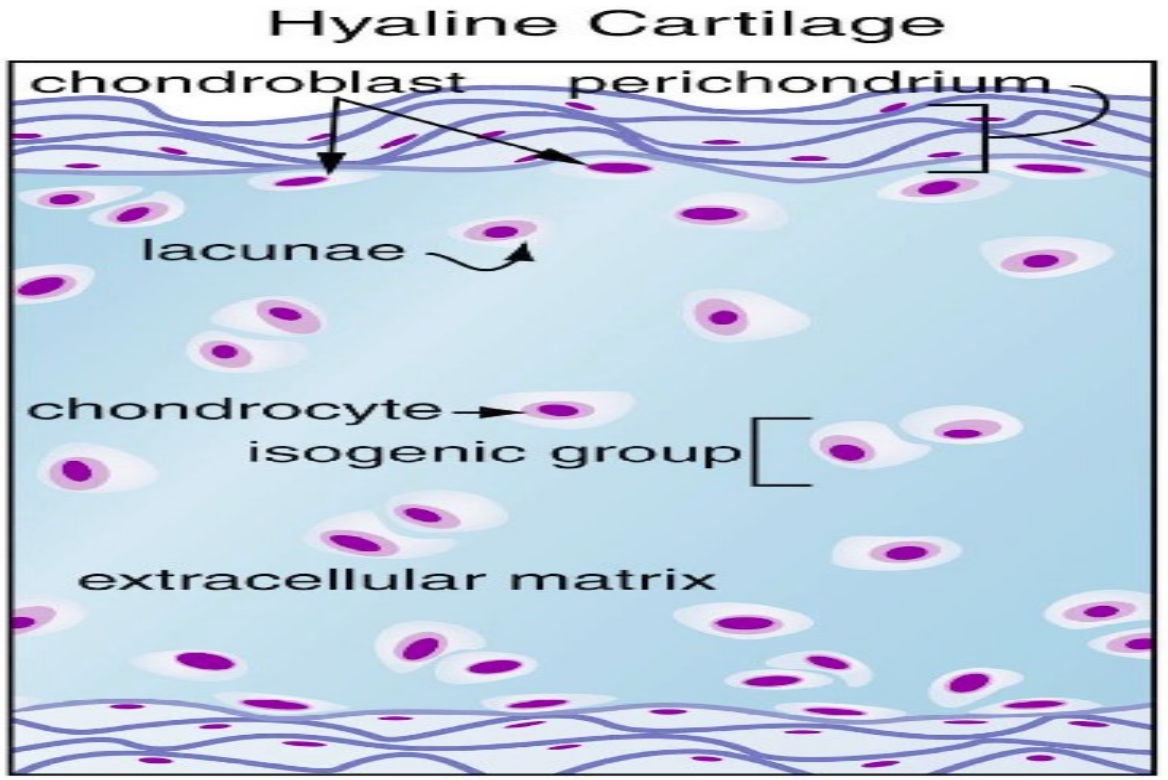
Structure of Hyaline Cartilage

1. Perichondrium
2. Cells
3. Matrix



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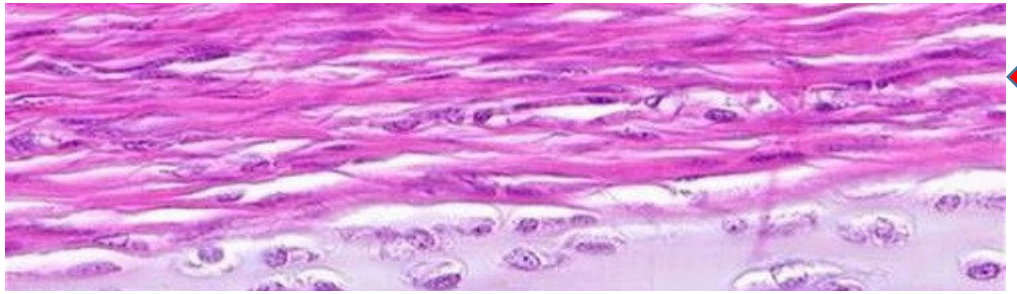

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Perichondrium

1- Outer fibrous layer

Collagen I, fibroblasts, blood vessels, and neural component

2- Inner chondrogenic (cellular) layer

1 or 2 rows of cartilage forming cells (**chondrogenic cells** & **Chondroblasts**)

Perichondrium

➢**It is a dense irregular connective tissue membrane that covers the cartilage.**

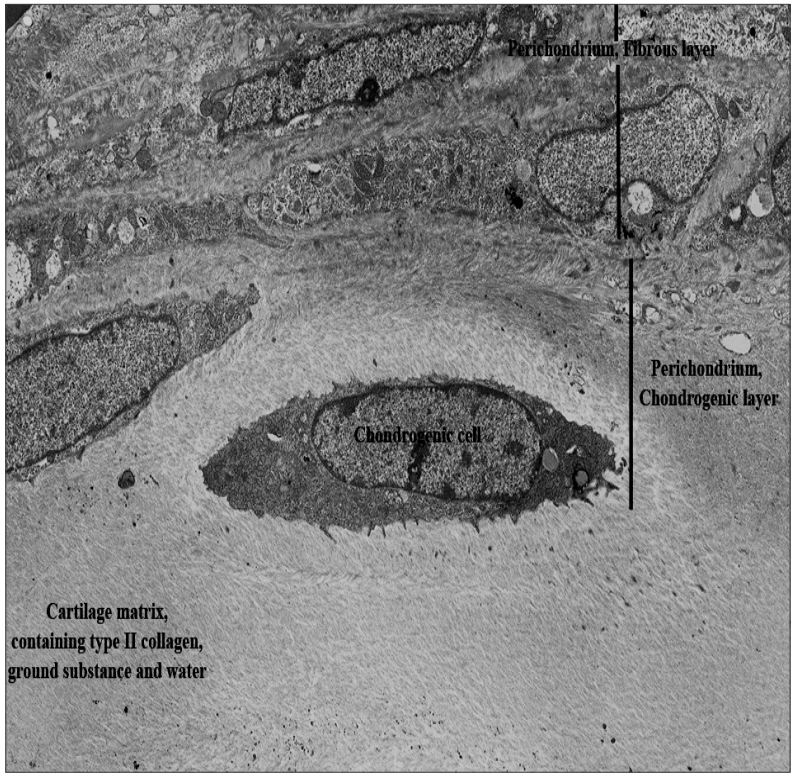
Function:

1. Supply nourishment to the **avascular** hyaline cartilage by **diffusion** (**except** for articular surface).
2. Growth of cartilage (**appositional**).
3. Repair & healing of damaged cartilage.

2- Cartilage Cells:

1- Chondrogenic Cells:

- **Origin:** UMC
- **Site**: inner chondrogenic layer of the perichondrium.
- **Shape**: flat or spindle.
- **L.M:** basophilic cytoplasm & ovoid flat nucleus.
- **E.M:** abundant ribosomes, few rER and golgi.
- **Fate**: they can divide and differentiate into chondroblasts



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2- Cartilage Cells:

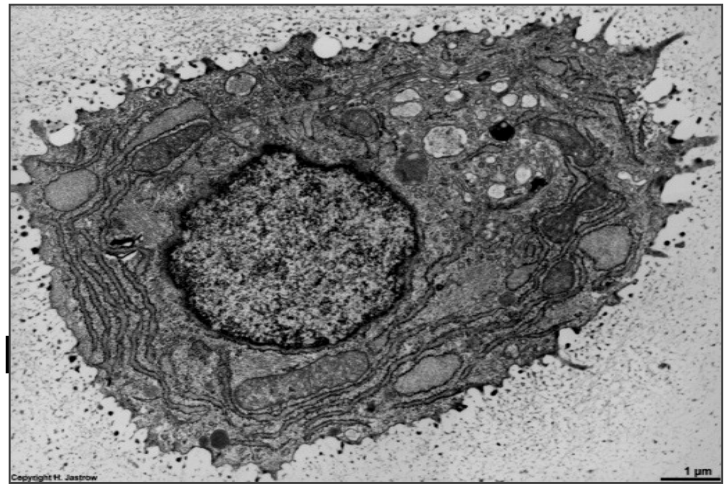
2- Chondroblasts:

- **Origin:** UMCs, chondrogenic cells or pericytes.
- Present in inner chondrogenic layer of perichondr
- **L.M.:** flat in shape, parallel to surface

having central oval vesicular **nucleus** & deep **basophilic cytoplasm**.

- **E.M.:** numerous mitochondria, ribosomes, rER & well-developed Golgi complex.
- **Function:** They **divide** & **secrete the matrix**.

Once surrounded by matrix, they become



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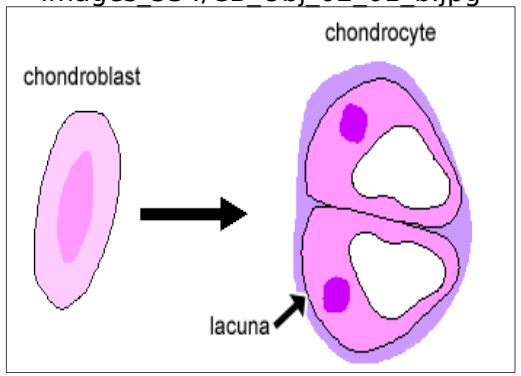

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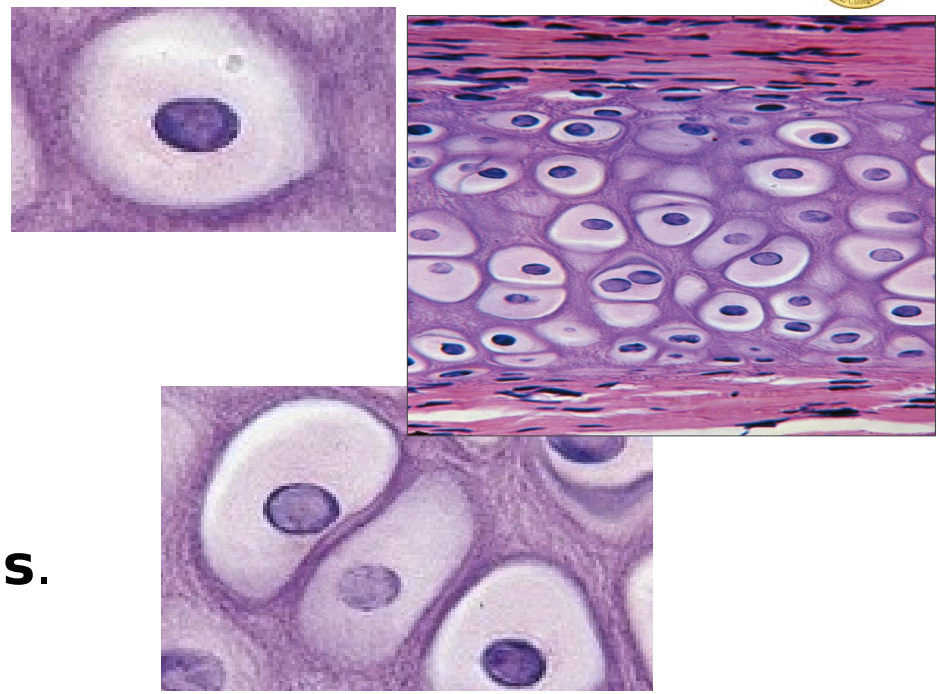
3- Chondrocytes:



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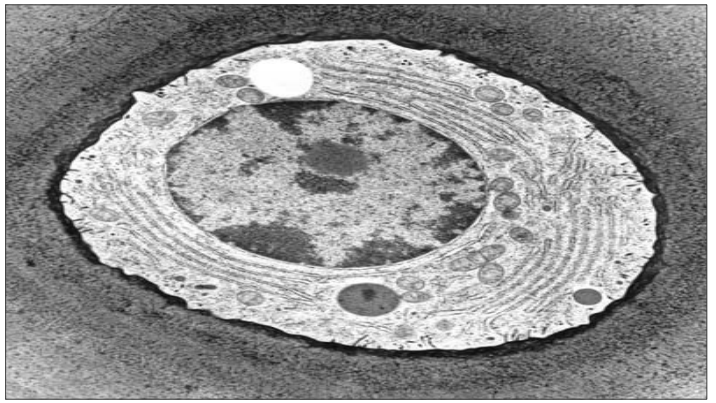


- **Origin:** chondroblasts
- **L.M:**

Shape:

Superficially: Oval single inside lacunae.

Deeper in the cartilage, they are round and may appear in groups of up to eight cells **cell nest** that originate from mitotic divisions of a single chondroblast and are called **isogenous aggregates**.

Nucleus is central, round & vesicular.

Cytoplasm is basophilic .

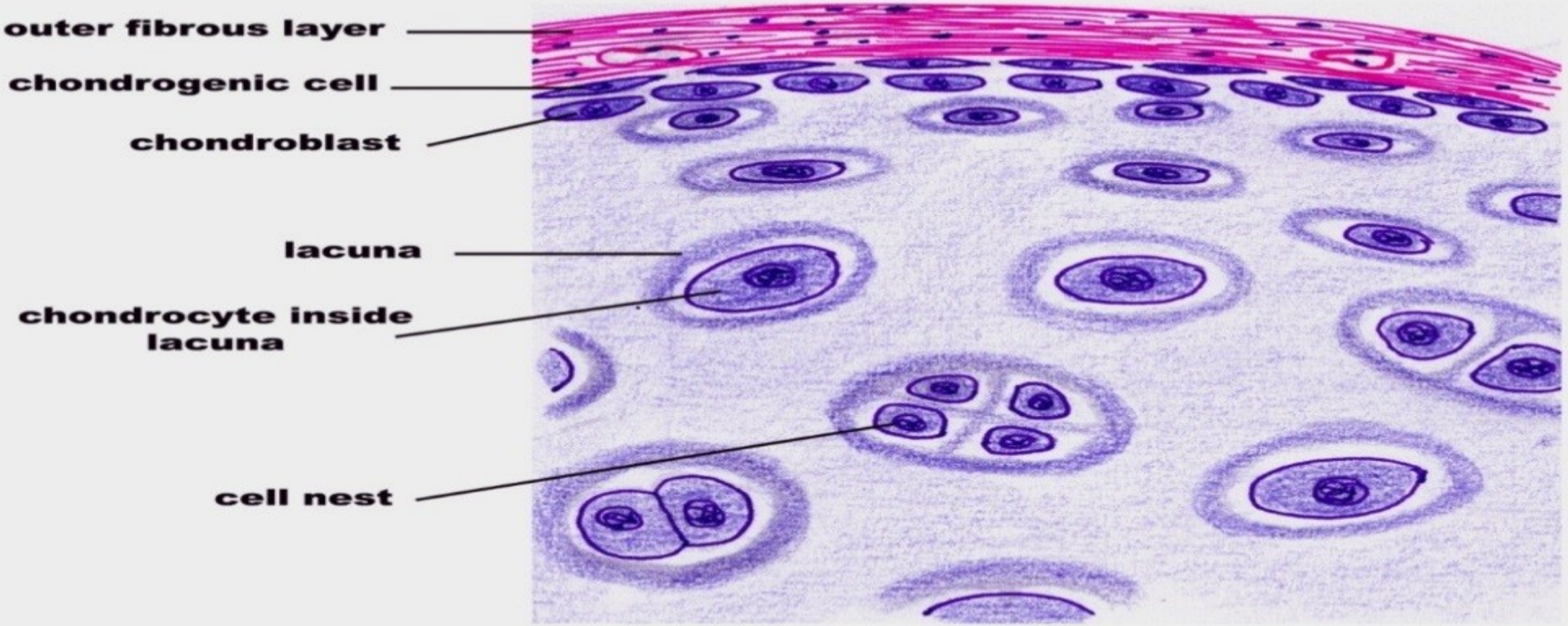
- **E.M:** protein secreting cells

(ribosomes- rER- Golgi - mitochondria)

- **Function:**

1- Synthesis & secretion of matrix of cartilage

2- Divide (interstitial growth)



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Lecture Quiz

- **Chondroblasts :**

A. Have deeply acidophilic cytoplasm
B. Are present inside lacunae
C. Lead to interstitial growth of cartilage
D. Are flat basophilic cells in perichondrium

Lecture Quiz

- **All about chondrocytes are true except:**

A. Non-dividable cells
B. Flattened at the periphery when are young
C. Have basophilic cytoplasm
D. Present in lacunae

3- Matrix of Hyaline Cartilage:

Fibers

-mainly **collagen** type **II** fibrils

Ground Substances

Tissue fluid

Proteoglycans & Glycosaminoglycans

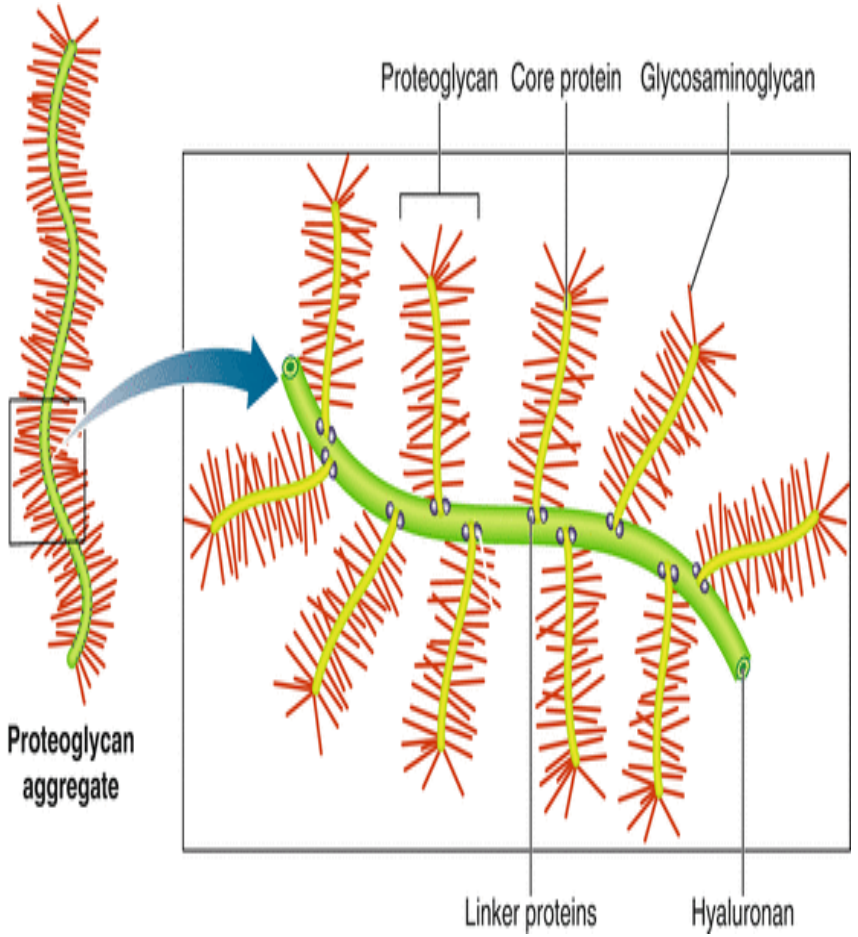
Glycoproteins

Causes of non apparent collagen II fibrils in H&E:

1. Have a refractive index almost the same as that of ground substances.
2. Have small submicroscopic dimensions.

Ground Substances:

- **Tissue fluid:** forming **75% of** cartilage **weight** The high content of **bound water allows cartilage to serve as a shock absorber**.
- **Proteoglycans:**
  Core of protein **aggrecan** with side chains of sulfated GAGs are attached .
  - **Glycosaminoglycans (GAGs):** Sulfated GAGs as Chondroitin sulfate, Keratan sulfate and non-sulfated Hyaluronic acid
  - **Glycoproteins:** as adhesive **chondronectin (**binds to GAG and integrins)



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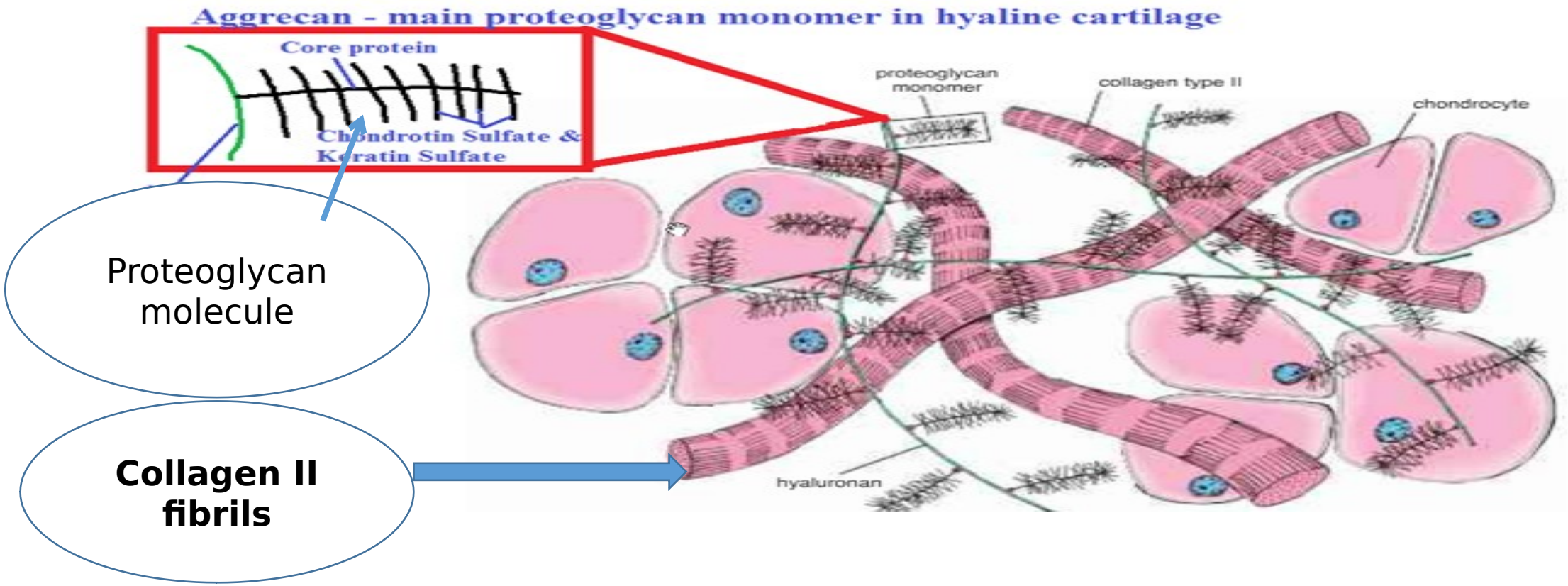
Matrix of hyaline cartilage

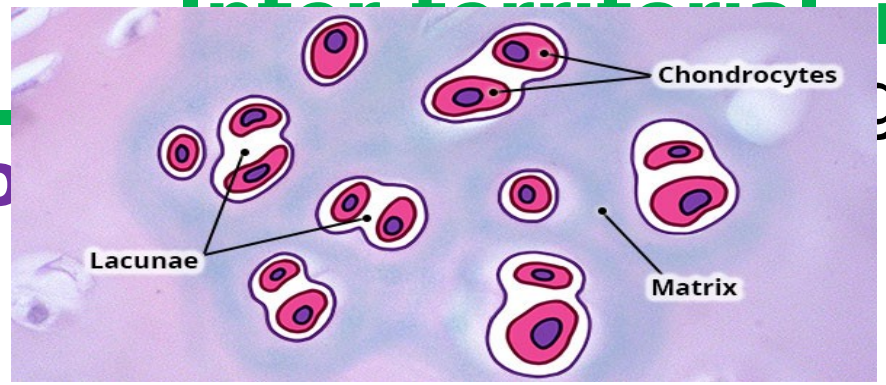


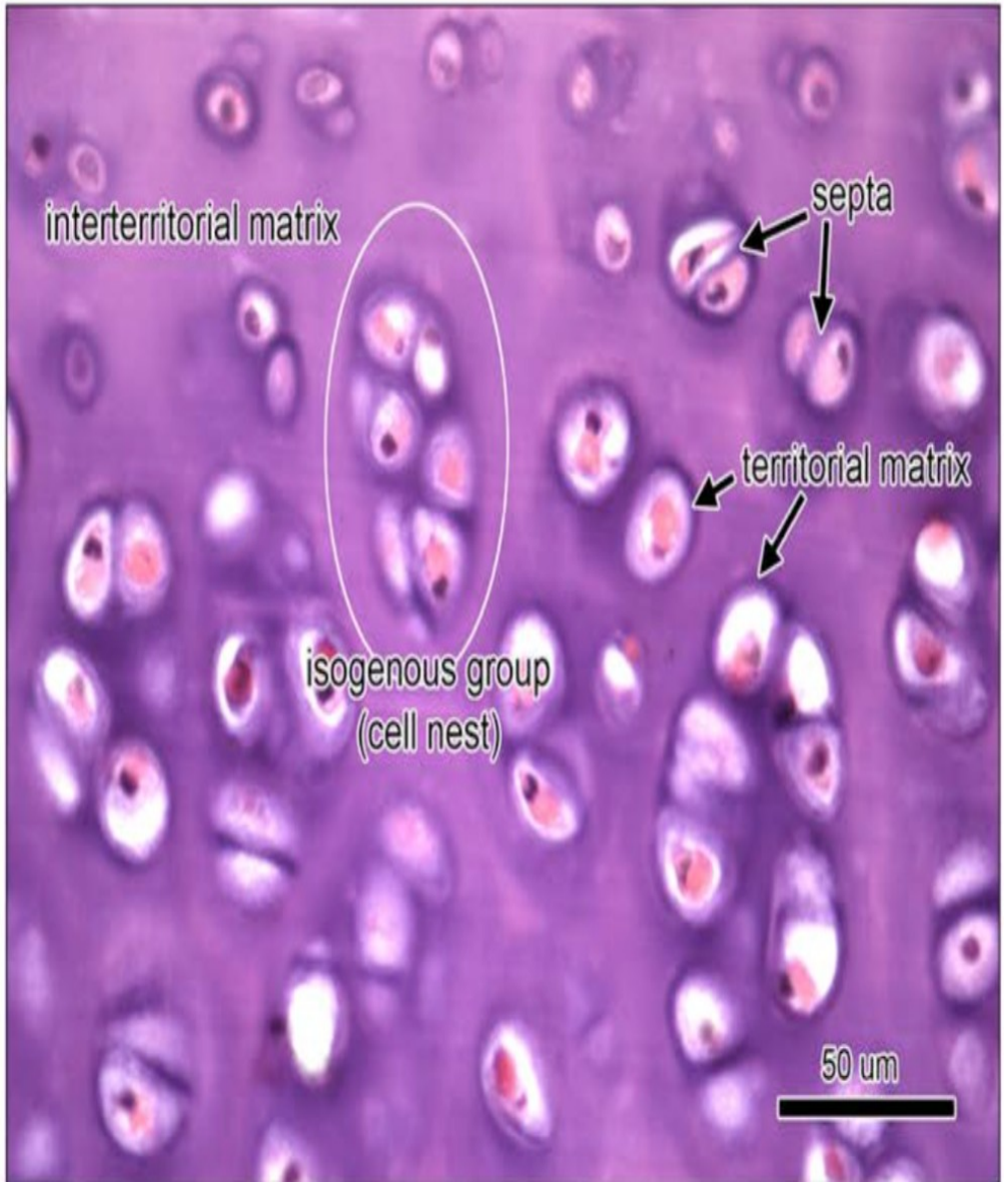
Its **semirigid consistency** is attributable to **water bound to the negatively charged hyaluronan and GAG chains** extending from proteoglycan core proteins, which are enclosed within a dense meshwork of thin type II collagen fibrils.

- Chondrocytes:→within **lacunae**

that are surrounded by deep basophilic capsular region or **territorial matrix (T.M.) due to increased content of sulfated glycosaminoglycans**.

Inter territorial matrix (I. g more co





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Staining Properties

- **Cause of matrix basophilia** → high content of chondroitin sulfate.
- **Cause of matrix metachromasia** → presence of GAGs.
- **Cause of matrix positive PAS staining** → its content of glycoproteins.
- **Changes with age**: partial calcification

Lecture Quiz

- **All the followings about hyaline cartilage are true except:**

A. Is found in fetal skeleton

B. Is non-vascular

C. Its matrix is acidophilic

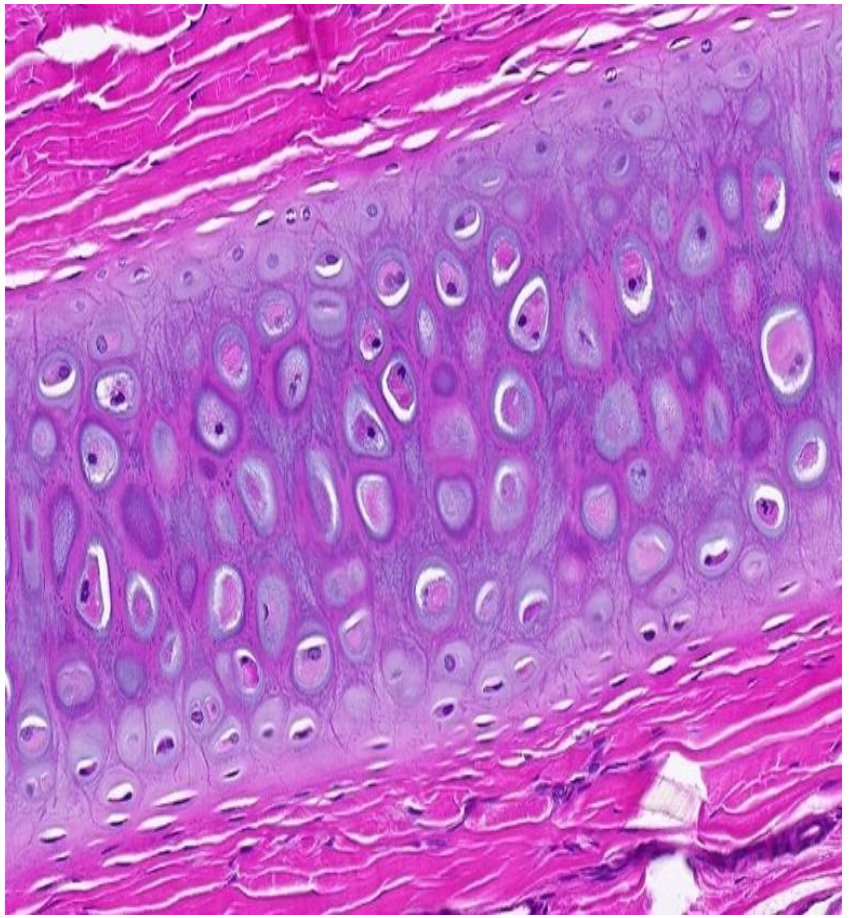
D. Receives its nutrition by diffusion from capillaries in perichondrium

Yellow Elastic Cartilage

- In the fresh state, it appears opaque and yellow in color.
- It is present in areas where more flexibility and elasticity is needed.

- Sites

1. Ear pinna.
2. External auditory meatus.
3. Eustachian tube.
4. Epiglottis
5. Tip of arytenoid cartilage of the larynx.



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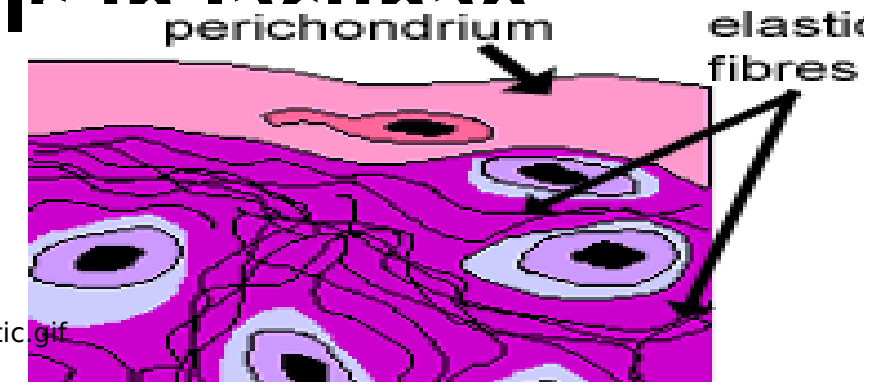
Yellow Elastic Cartilage

Structure

- Similar to hyaline cartilage, but matrix contains elastic fibers forming a network that surround the lacunae of chondrocytes.
- It is more cellular with less matrix.
- Cells are present singly or in a group of two cells in lacunae



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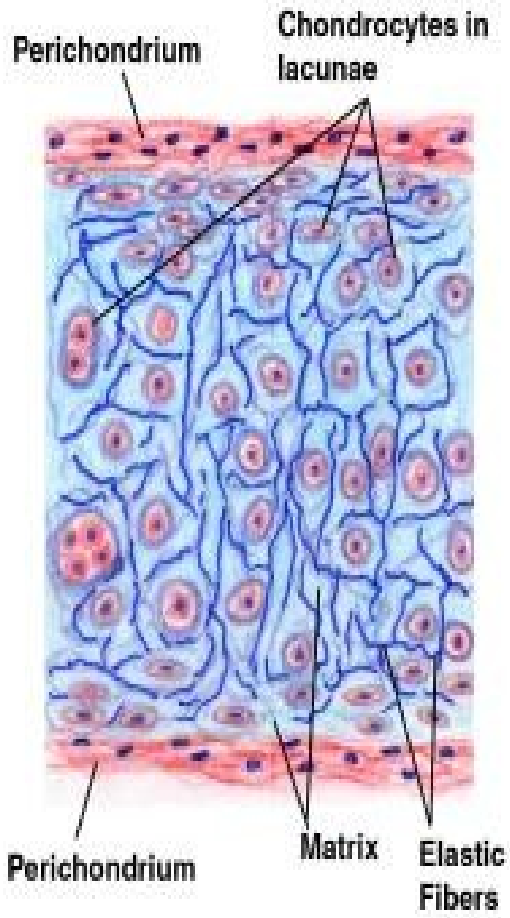

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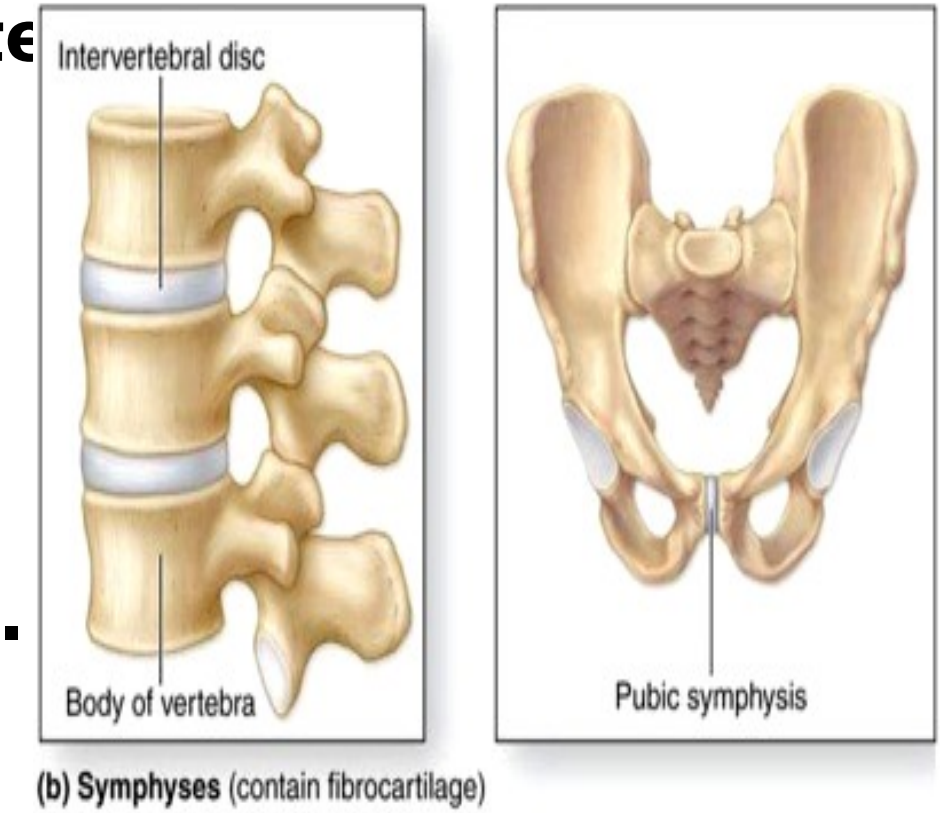
White Fibro-cartilage

- In the fresh state, it appears white

Sites (areas of severe stress)

- Inter vertebral disc.
- Symphysis pubis.
- Lips of glenoid cavity and acetabulum.
- Semilunar cartilage of knee joint.
- Site of insertion of tendons into bones



(b) Symphyses (contain fibrocartilage)

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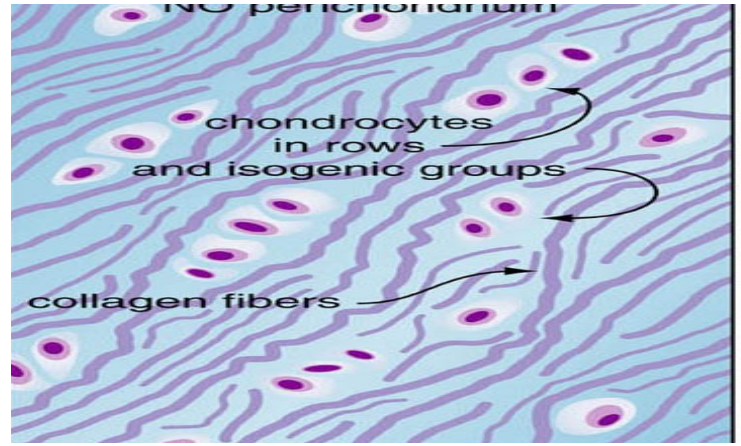
White Fibro-cartilage

- **Structure**

1. Areas of **chondrocytes and hyaline matrix** separated by other areas of **fibroblasts and dense bundles of type I collagen**
2. **The chondrocytes are present in rows embedded in basophilic ground substance.**
3. **It is devoid of perichondrium, BUT the associated collagen bundles contain blood vessels.**



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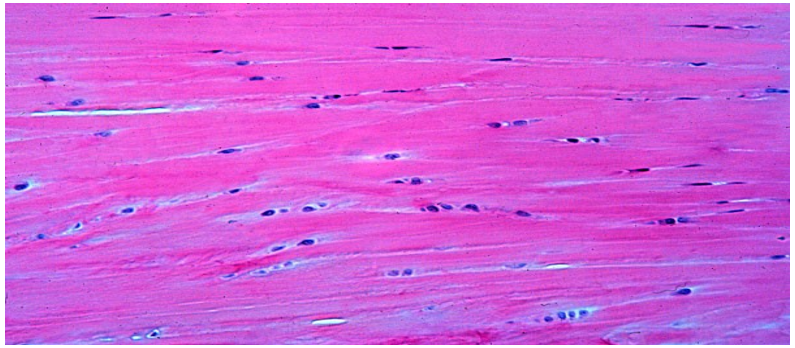
Character and Function

- **It is tense and resist stretch due to the presence of high content of collagen fibers.**



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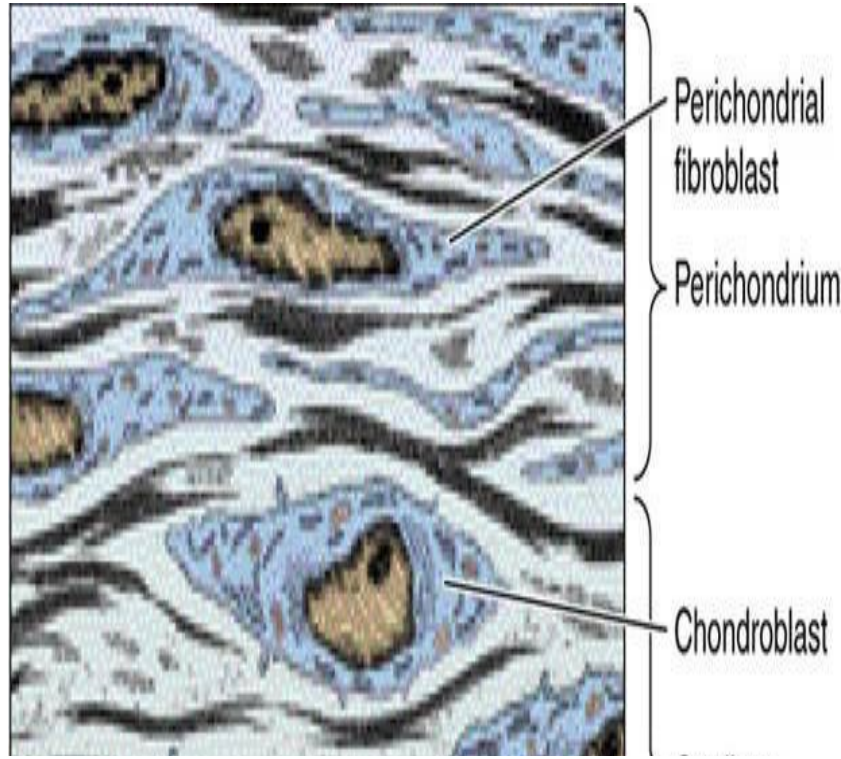
N.B:

- **All types of cartilage are surrounded by perichondrium**

EXCEPT:

1. **Articular cartilage.**
2. **White fibrocartilage.**



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Nutrition Of Cartilage

- Cartilage is avascular, it takes its oxygen and nutrients from the perichondrial blood vessels by diffusion through the matrix(which is suitable to that by its high content of water 70 -75%).

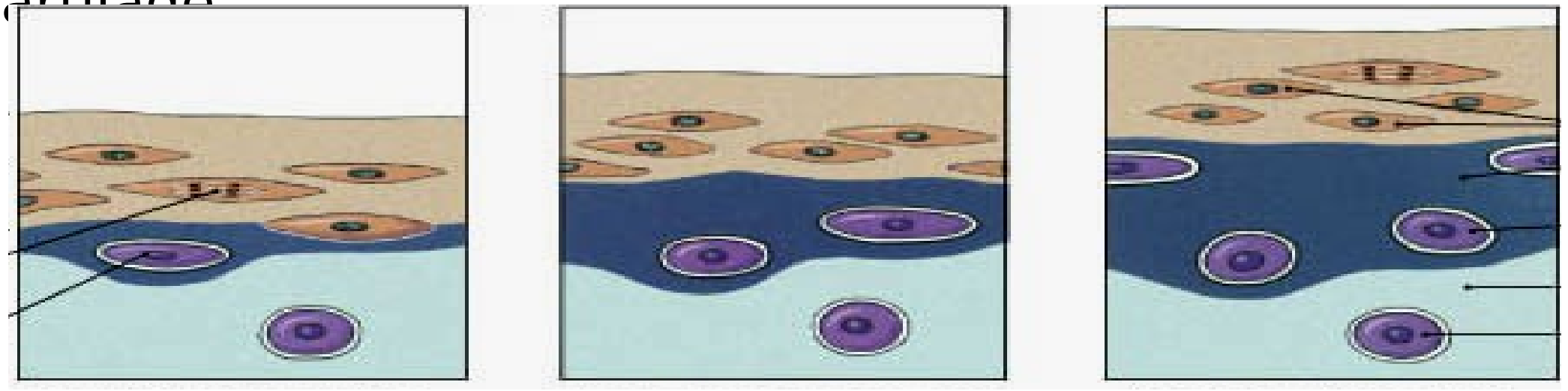
- In articular cartilage (which has no perichondrium) it gets its oxygen and nutrients from the synovial fluid of the joints.

- Also, in white fibro-cartilage (no perichondrium) it gets its needs from the blood vessels present in-between the bundles of collagenous fibers.

Growth of Cartilage

1- Appositional growth:

By differentiation of new chondroblasts in the inner chondrogenic layer, they divide and secrete matrix resulting in addition of new layers to the outer surface of cartilage



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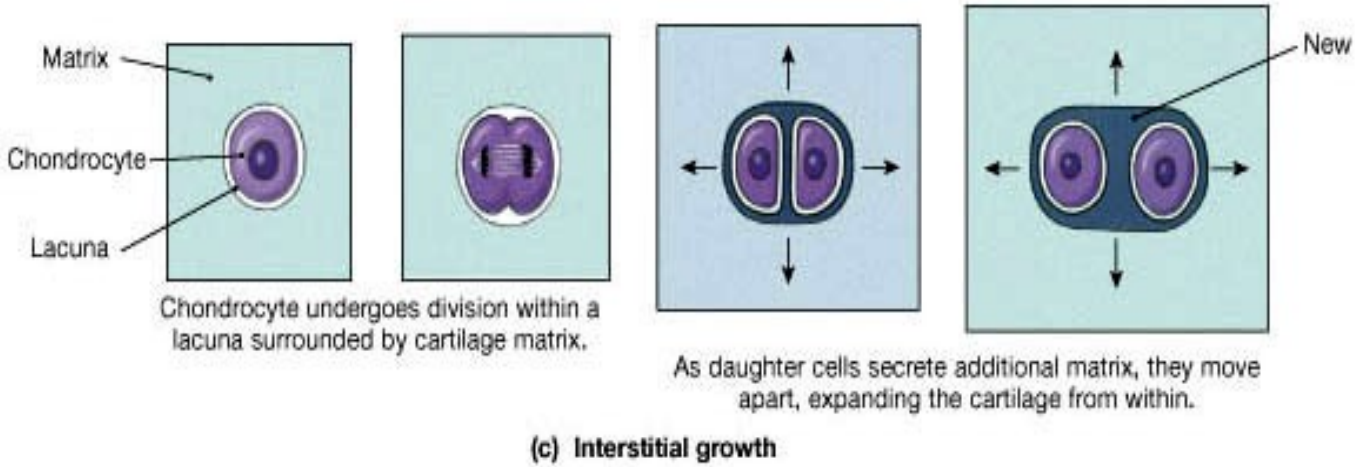
Growth of Cartilage

2- Interstitial growth:

By chondrocytes, they divide inside their lacunae and secrete new matrix resulting in growth of cartilage from within.



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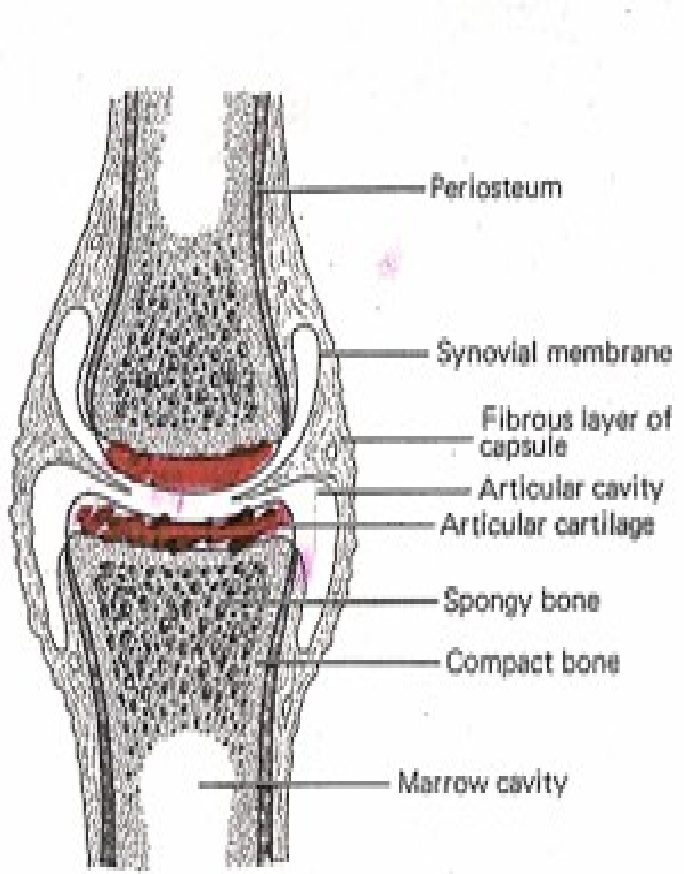
Medical Applications

Osteoarthritis:

- Some joints like knee and hip are subjected to persistent wear and tear over the years.
- This leads to degeneration of the articular cartilage.
- Friction between the two bony surfaces cause pain.



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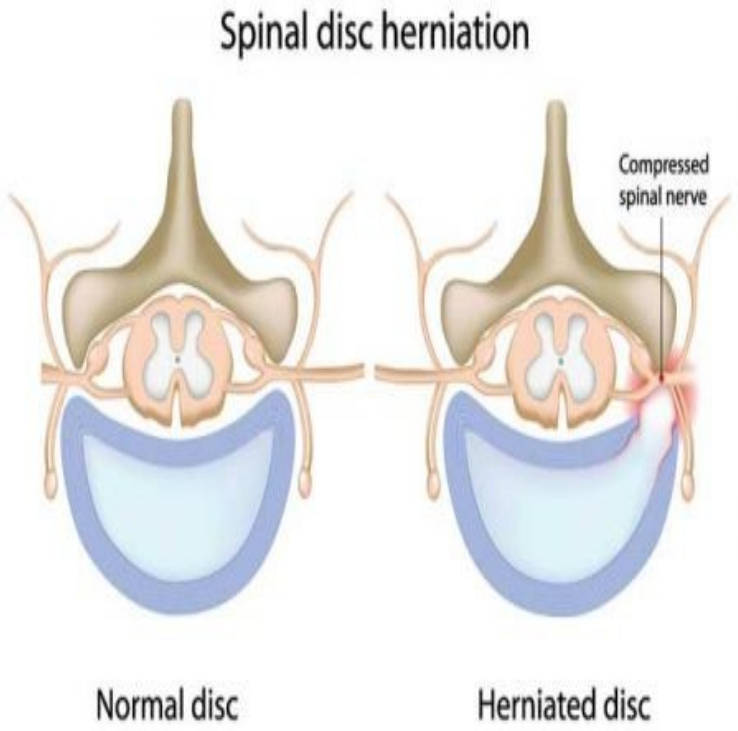
Medical Applications

Disc prolapse:

- With advanced age, the **white fibrocartilage** of the **intervertebral disc** becomes thinned and weakened.
- Slipped discs may also caused by abnormal heavy loads on the intervertebral discs.
- This led to herniation or prolapse of the disc which may cause pressure on the spinal nerves leading to sever pain.
- This condition commonly occurs at the lumbar region.



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Fibrocartilage	Elastic cartilage	Hyaline cartilage	
Absent	Present	Present Except articular cartilage	**Perichondri**
Arranged in rows between bundles	Arranged single or in pairs inside lacunae	Arranged single & in groups inside lacunae	**Chondrocyt**
Acidophilic due to collagen I & between cells small amount of basophilic matrix with some collagen II	Basophilic , contains elastic & collagen II.	Basophilic , contains mainly collagen II.	**Matrix**
-Intervertebral discs -Semilunar cartilage -Symphysis pubis -Lip of acetabulum & glenoid -Near tendon insertion	-Ear pinna -External ear -Eustachian tube -Epiglottis -Tip of arytenoid cartilage of the larynx	-Articular cartilage -Costal cartilage -Cartilage of respiratory passages -Fetal skeleton -Epiphyseal plate of long bone	**Location**

Lecture Quiz

- **Vascular type of cartilage is**

a)Hyaline cartilage

b)White fibrocartilage

c)Elastic cartilage

d)None of the above

Lecture Quiz

- **Oxygen and nutrient from perichondrial blood vessels reach the chondrocytes via:**

a) Canaliculi
b) Capillaries
c) Sharpey’s fibers
d) Diffusion

Lecture Quiz

- **Which of the following is <u>true</u> concerning white fibrocartilage**

a)It is not covered by perichondrium

b)Cells receive their nourishment from synovial fluid.

c)Matrix contains only Type I collagen.

d)Is basophilic in staining

Key Points

- Histological structure of hyaline cartilage.
- Histological structure of perichondrium.
- Microscopic structure & function of different types of cartilage cells (chondrogenic, chondroblast and chondrocytes).
- Microscopic structure of the matrix of hyaline cartilage.
- Differentiate between the three different types of cartilage (Hyaline, Elastic & white-fibrocartilage).
- Staining properties of cartilage.
- Nutrition, growth and medical application of cartilage.

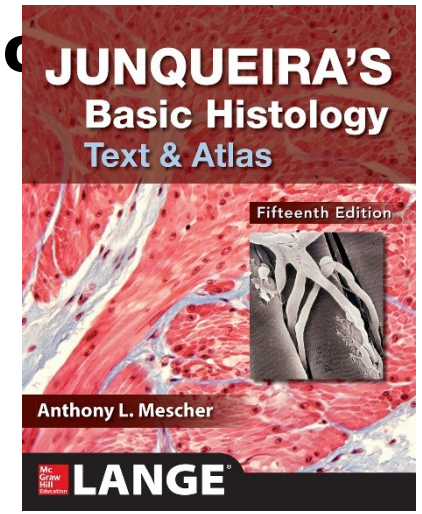
Summary

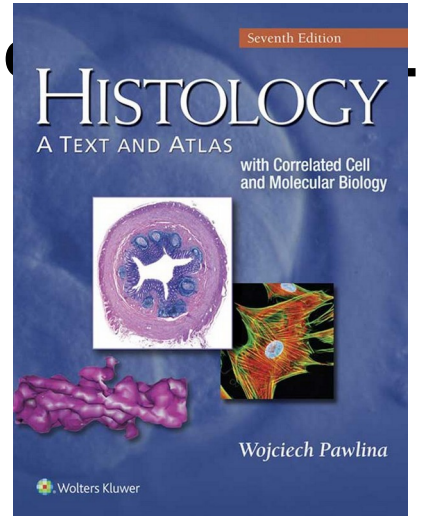
1. Hyaline cartilage is the most common type of cartilage
2. No perichondrium in articular cartilage and white fibrocartilage
3. Chondroblasts are not present in lacunae.
4. Elastic cartilage has elastic fibers in their matrix
5. White fibrocartilage has collagen type I in between the rows of chondrocytes
6. Cartilage grows by appositional and interstitial growth
7. The defective microscopic cartilage structure in hyaline and white fibro-cartilage.

SUGGESTED TEXTBOOKS

1. **Junqueira's Basic Histology: Text and Atlas, 15th Edition by Anthony Mescher (2018)**

2. **Histology a text and atlas with correlated cell and molecular bio Pawlina 7th e .6)**





THANK YOU